Can Culture be a Salient Predictor of Test-Taking Engagement? An Analysis of Differential Noneffortful Responding on an International College-Level Assessment of Critical Thinking

Joseph A. Rios^{ab} & Hongwen Guo^a

^aEducational Testing Service, Princeton, NJ

^bUniversity of Minnesota, Minneapolis, MN

Author Note

Joseph A. Rios is now an assistant professor in the department of educational psychology at the University of Minnesota.

The authors would like to thank Lauren Bauser and Lin Gu for their assistance in obtaining the data, Jun Xu for her help with data cleaning, and Marna Golub-Smith, Usama Ali, and Jodi Casabianca-Marshall from Educational Testing Service for their helpful feedback on an earlier draft.

Author contribution statement:

Rios conceived of the presented idea minus the mixed lognormal distribution-based method (MLN), which was conceived by Guo. Both authors conducted data analyses, while Rios interpreted the findings, and drafted the article. Guo provided feedback on the draft and Rios conducted critical revisions of the article throughout the review process. Final approval of the version to be published was made by both authors.

Correspondence concerning this article should be sent to Joseph A. Rios, University of Minnesota, 56 E. River Road, Minneapolis, MN 55455.

Email: jrrios@umn.edu

Cite as:

Rios, J. A., & Guo, H. (2020). Can culture be a salient predictor of test-taking engagement? An analysis of differential noneffortful responding on an international college-level assessment of critical thinking. *Applied Measurement in Education*. Advance online publication. doi.org/10.1080/08957347.2020.1789141

Abstract

The objective of this study was to evaluate whether differential noneffortful responding (identified via response latencies) was present in four countries administered a low-stakes college-level critical thinking assessment. Results indicated significant differences (as large as .90 *SD*) between nearly all country pairings in the average number of noneffortful responses per test taker. Furthermore, noneffortful responding was found to be associated with a number of individual-level predictors, such as demographics (both gender and academic year), prior ability, and perceived difficulty of the test, though, these predictors were found to differ across countries. Ignoring the presence of noneffortful responses was associated with: (a) model fit deterioration as well as inflation of reliability, and (b) the inclusion of non-invariant items in the score linking anchor set. However, no meaningful differences in relative performance were noted once accounting for noneffortful responses. Implications for test development and improving the validity of score-based inferences from international assessments are discussed.

Keywords: noneffortful responding, low test-taking effort, international assessments, validity

Can Culture be a Salient Predictor of Test-Taking Engagement? An Analysis of Differential Noneffortful Responding on an International College-Level Assessment of Critical Thinking

Due to the increase of globalization and the transition from production- to knowledge-based economies in Westernized nations, there has been rising interest in comparing student performance internationally since the creation of the First International Tests in Mathematics (FIMS) in 1964. International assessments have the potential to provide educational stakeholders with information that allows them to identify areas of student strengths and weaknesses at the national-level as well as examine the relationship between student performance and factors that may impact performance, which may provide a basis for prescribing national education policy reform. Although international assessments have the potential for great use, there have been growing concerns over the validity of score-based inferences made from such assessments due to sampling, test development, and technical psychometric issues (e.g., Hambleton, Merenda, & Spielberger, 2004; Matsumoto & van de Vijver, 2011; Pizmony-Levy et al., 2014). One validity issue that has received minimal attention in the international assessment literature is the assumption that test takers from different cultures/countries put forth equal test-taking effort (Gneezy et al., 2017). If this assumption is untenable, test performance will not reflect the skills, abilities, or proficiencies being assessed, and consequently, may lead to inaccurate performance comparisons between countries. This paper examines an international assessment of critical thinking to evaluate whether differential test taking effort is present among countries, and if so, the impact that it can present in terms of psychometric properties and country rankings.

Test-Taking Effort: A Validity Threat to Score-Based Inferences from Low-Stakes Tests

Although large-scale international assessments provide significant information for policymakers, educators, and researchers domestically and globally, they like most group-based assessments are low-stakes as the actual test takers bear little to no personal consequences for

their test performance. Under such a circumstance, according to Expectancy-Value Theory, a student's test-taking effort on the assessment is impacted by their desire to perform well on, subjective interest in, extrinsic value associated with, and perception of resource allocation required to complete the task (Wigfield & Eccles, 2000). Previous research that spans over 20 years has shown that across numerous countries students tend to place little subjective value on assessment results, and ultimately, test-taking efforts are decreased when the test-stakes are low (see Wise, 2009, for a review). Test takers can express low test-taking effort in two ways: (a) completely disengage and not respond, or (b) noneffortfully respond, which is defined as providing a response with intentional disregard for item content. The latter behavior is the focus of this paper.

Noneffortful responding has been found to bias both perceptions of measurement quality as well as lead to inaccurate aggregate-level score-based inferences. In regard to measurement quality, previous research has found that noneffortful responding can result in: (a) inflated item difficulties as well as deflated item discriminations (e.g., van Barneveld, 2007), (b) biased item and test information estimates (e.g., van Barneveld, 2007), (c) spurious inflation of classical test theory (CTT) score reliability estimates (e.g., Wise & DeMars, 2009), (d) erroneous flagging of differential item functioning (e.g., DeMars & Wise, 2010), (e) inaccurate construct dimensionality (e.g., Kam & Meyer, 2015), (f) decreased correlations with external variables (e.g., Wise, 2009), and (g) biased linking coefficients (Mittelhäuser, Béguin, & Sijtsma, 2015). In terms of aggregate-level score-based inferences, noneffortful responses comprising as little as 6% of the total data matrix has been found to underestimate mean performance by more than .20 *SD* (Rios, Guo, Mao, & Liu, 2018). This underestimation of mean performance is associated with biased: a) treatment effects (e.g., Osborne & Blanchard, 2011), b) achievement gains (e.g.,

Wise & DeMars, 2010), and c) value-added estimates of teacher effectiveness (e.g., Wise, Ma, Cronin, & Theaker, 2013). Clearly, these results indicate that noneffortful responding is potentially a major threat to the validity of score-based inferences from low-stakes assessments, such as those used for international comparative studies.

Differential Test-Taking Effort across Countries on International Assessments

Although there has been extensive research on the topic of test-taking effort, many of these endeavors have focused on relatively homogenous populations based in a single country. To date, there have been very few studies that have examined potential differences in test-taking effort between countries on international assessments. This is troubling as individuals' attitudes around, emotions toward, and behaviors on assessments may differ largely by culture/country (Harris & Brown, 2016). As an example, it is possible that test takers from collectivist cultures may place greater value on low-stakes assessments (i.e., there are little to no personal consequences for test performance) developed for providing group-level feedback (e.g., institutional or state-level accountability) than test takers from individualistic cultures due to differences in the emphasis placed on the needs and goals of the group. In such a case, it is expected that test-taking effort would be higher for test takers from collectivistic cultures as task value is positively associated with effort (Penk & Schipolowski, 2015). Such an example highlights the importance of taking into consideration culture when bearing in mind the potential biasing effect that differential noneffortful responding can have on international comparisons.

While there has been limited research on differential test-taking effort in international comparative assessments, three main findings can be taken away from prior work on this topic. First, across countries, test-taking effort has been found to have a positive association with performance on international assessments (i.e., the more students try, the higher their score; Boe,

May, & Boruch, 2002; Eklöf, Pavešič, & Grønmo, 2014; Goldhammer, Martens, Christoph, & Lüdtke, 2016). Second, across studies, the presence of differential test-taking effort between countries has varied. As an example, when using response latencies (i.e., the time between the presentation of an item and a response) as a proxy of test-taking effort, Goldhammer et al. (2016) found significant differences in test-taking effort between countries on the 2012 PIACC assessment. Specifically, on one assessment, Russian test takers were observed to possess a noneffortful response rate (16.7%) that was over four times greater than the country with the fewest noneffortful responses, Austria (4.1%). In contrast, Eklöf et al. (2014) found negligible differences in self-reported effort between countries when comparing test takers from Sweden, Norway, and Slovenia that were administered the 2008 TIMSS advanced mathematics test. Third, higher rates of noneffortful responding have been shown to be associated with both lower performing test takers and countries (Debeer, Buchholz, Hartig, & Janssen, 2014).

Rationale for the Current Study

Although there have been studies that have examined whether differential noneffortful responding between countries occurs on international assessments, the results are limited in a number of ways. First, across studies, it is inconclusive whether there are substantial differences in noneffortful responding between countries due largely to divergent methodological approaches taken to identify proxies of this behavior. Second, there are numerous moderators that impact test-taking effort (see Wise and Smith, 2016, for a review), yet, to date, there has been very little examination of whether these moderators are the same across different countries¹. Lastly, and most importantly, there has not been an examination of the actual impact of differential noneffortful responding on mean score comparisons between countries. To address

¹ Goldhammer et al. (2017) conducted subgroup comparisons of test-taking effort based on moderators, however, the data were aggregated across all countries and the moderators were not jointly modeled.

the limitations in the literature, the objective of this study was to investigate whether culture was a salient predictor of test-taking engagement on an international college-level assessment of critical thinking administered to test takers from four distinctive countries. In addressing this objective, we proposed a new procedure for identifying noneffortful responses and answered the following three research questions:

1. Is there statistically significant differential noneffortful responding (based on using response latencies as a proxy) between four countries (two Western and two non-Western) on an international higher education assessment of critical thinking?
2. What are the group- and individual-level predictors associated with noneffortful responding on this assessment? Do they differ between the countries examined?
3. If differential noneffortful responding is present in our sample, what is its impact on the relative performance of the countries examined?

Results from this study have the potential to inform practitioners about the role of culture on test-taking effort in cross-national comparisons of critical thinking.

Method

Sample

Data from four distinctive countries² were analyzed: Country 1 ($n = 3,186$), Country 2 ($n = 3,574$), Country 3 ($n = 1,679$), and Country 4 ($n = 11,440$). Within each country, four year universities were randomly sampled as part of an effort for institutional improvement and accountability. Students majoring in science, technology, engineering, and mathematics (STEM) fields were sampled within each university. The number of institutions sampled within each

² As part of the agreement to use this secondary dataset, country names could not be exposed; however, as of June 2018, each of the four countries sampled belonged to the G20 international forum and possessed economies that were in the top 12 in the world. Two of the four countries were tested in non-English languages.

country ranged from 34 to 168, and the average number of test takers from each institution within each country ranged from 49 to 99 students. For further sample details, see Table 1.

Instrument

One form of the HEIghten Critical Thinking (CT) Assessment, which was originally developed to test learning outcomes across two- and four-year U.S. higher education institutions, was administered to all students in each participating country. This 45-minute computer-based assessment is comprised of 26 selected-response items (combined single select, select x number of options, and select all that apply multiple-choice questions) that are scored dichotomously (chance rates ranged from .04 to .25). Assessment tasks include critical thinking sets and short arguments or informational passages (see Liu, Frankel, & Roohr, 2014, for more details about the measure). Based on data from over 3,000 test takers in 35 two- and four-year colleges, validity evidence was provided to support a unidimensional model (this model was supported for all countries in this study³), adequate individual- and institutional-level reliability, and a positive relationship between the total score from the assessment and high school GPA, college GPA, SAT/ACT scores, and students' self-reported critical thinking skills (Liu, Mao, Frankel, & Xu, 2016). To accommodate test takers from Countries 2 and 3 in which English was not the language of instruction, non-English versions were created. This was accomplished as follows: (a) two translators (familiar with both the target language and culture) identified by a professional linguistic company independently adapted the original content to the desired target language, (b) they then reconciled any differences, (c) the reconciled draft was sent to the principal investigators for their review who were native speakers of the targeted languages, (d)

³ Unidimensional models were fit separately for each country's data using confirmatory factor analysis. Based on the recommendations of Hu & Bentler (1999), all data were found to adequately fit the model. This finding provided evidence of construct equivalence across the participating countries.

additional edits were made, and (e) the adequacy of the final version was verified by an independent translator from the professional linguistic company. In addition, the measures were piloted with a small number of university students in each targeted country to ascertain whether there were any perceived language issues.

Procedure

Within each country, test takers were recruited by their respective institutions relying primarily on volunteering. The test was administered via computers in dedicated computer labs on the campus of each institution. As part of the test administration, proctors ensured that everyone received the same standardized instructions. These instructions notified test takers that their score on the assessment would have no impact on their grades or academic standing, and that they should try their best as the information from the assessment would be useful to their institution. Test takers were given 45-minutes to complete the assessment. A posttest survey was administered that contained approximately 20 questions that garnered demographic, academic, and testing experience information.

Analyses

Identification of noneffortful responses. One strategy that has been applied to identify noneffortful responding is to utilize response latencies. As this is an indirect proxy of test-taking effort, it assumes that a response is invalid if given in an amount of time that does not allow the test taker to fully read the item stem and response options (Schnipke & Scrams, 1997). This approach is advantageous in that it is an unobtrusive indicator of actual individual student behavior on an item-by-item basis. There are numerous procedures for determining an appropriate response time that indicates a noneffortful response (see Wise, 2017 for a review);

this study employed three of these approaches. Thresholds for all procedures described below were calculated in *R* (R Core Team, 2019).

The first, referred to as the three-second rule (SEC3), states that any response provided in three seconds or less is classified as a noneffortful response (e.g., Kong, Wise, & Bhola, 2007). One limitation associated with SEC3 is that the threshold does not differ by item, and consequently ignores the impact of variability of item length, content, and difficulty on item response times. To address this issue, Wise and Ma (2012) proposed the normative threshold procedure (NT10), which varies thresholds across items by classifying a response as noneffortful if it is provided in less than 10% of the median item response time across the sample. In this study, the median item response time was calculated separately for each country.

An additional item-specific threshold procedure employed in this study is referred to as a hybrid rule (HYBRID). This procedure defines a threshold using either the cumulative proportion correct (CUMP) procedure proposed by Guo et al. (2016) or a new procedure referred to as the mixed lognormal distribution-based method (MLN). The CUMP method identifies the minimum response time for an effortful response as the time on the test (seconds) in which the cumulative proportion correct rate first begins to be consistently above the chance rate for the studied item. One limitation of this method is that thresholds cannot be defined for difficult items in which the total proportion correct is at or below the chance rate. When this was the case, we employed the MLN method, which can be viewed as an adaptation of the visual inspection (VI) method (see Kong et al., 2007, for more details). Specifically, it is assumed that if test takers are noneffortfully responding to an item, a bimodal response time distribution should be observed in which the lower mode represents noneffortful responding and the upper mode indicates effortful responding. The MLN method employs an automated process that utilizes an empirical response

time distribution, fits a mixed log normal distribution, and then locates the lowest point between the two modes of the distribution, which is set as the threshold. More specifically, let $Y = \log(X)$ be the logarithm transformation of the original response time X , and let $Y_1 \sim N(\mu_1, \sigma_1) = f_1(y)$ and $Y_2 \sim N(\mu_2, \sigma_2) = f_2(y)$ denote the components of two normal distributions (assuming $\mu_1 < \mu_2$). The distributions of Y is represented by:

$$f(y) = \pi_1 f_1(y) + \pi_2 f_2(y), \quad (1)$$

where π_1 and π_2 are the proportions of the two normal density functions. Then the density function of the original response time X is:

$$g(x) = \frac{f(\log x)}{x} = \pi_1 \frac{f_1(\log x)}{x} + \pi_2 \frac{f_2(\log x)}{x}. \quad (2)$$

The threshold is defined as the time point $x \in (\mu_1, \mu_2)$ where $g(x)$ reaches the minimum value (which is also the intercept of f_1 and f_2 ; see Appendix for R syntax to calculate thresholds for the hybrid procedure). HYBRID thresholds were calculated separately for each country to account for differences in the number words per item across languages as this variability could account for differential response times across countries.

Validating procedures for identifying noneffortful responses. Similar to Kong et al. (2007), two validity checks were employed to ensure that the threshold procedures employed accurately identified noneffortful responses. The first validity check examined the proportion correct of noneffortful responses. In doing so, it was assumed that noneffortful responses would possess a proportion correct equal to chance level. As the items examined for the CT assessment possessed chance rates that ranged from .015 to 0.25, the expected average chance rate across all items (.193) was compared to that of the observed for each procedure and country. The second approach employed was to examine the convergent validity between the degree of effortful responding (response time effort; RTE) and both total testing time and raw scores. RTE was

defined as the proportion of item responses that were effortful (Wise & Kong, 2005). As RTE is expected to be non-normal (e.g., Kong et al., 2007), Spearman's correlation procedure was used. It was expected that as a test taker put forth more effort, one would observe a strong positive linear association with both testing time (i.e., increased effort would be associated with spending more time on the test), and test performance (i.e., on average, increased effort would be associated with improved test performance). Therefore, the threshold procedure with both an observed proportion correct rate for noneffortful responses that was closest to the expected chance rate, and the strongest convergent validity between effortful responding with total testing time and test performance would be judged to be most appropriate, and thus, used for all remaining analyses.

Modeling potential moderators of noneffortful responding. The *lme4* package (Bates, Maechler, Bolker, & Walker, 2018) in *R* was used to perform a linear mixed effects analysis of the relationship between the number of noneffortful responses and person- and university-level characteristics, taking into consideration that test takers (level-1) were nested within universities (level-2). Based on prior literature, the following four person-level characteristics were evaluated to see if they were related to noneffortful responding in our samples: (a) gender (males have been shown to noneffortfully respond more than females; e.g., DeMars, Bashkov, & Socha, 2013), (b) age (older test takers tend to noneffortfully respond more than younger test takers; e.g. Rios & Liu, 2017), (c) prior ability (lower ability test takers have been found to noneffortfully respond more than higher ability test takers; e.g., Rios et al., 2017), and (d) perceived test difficulty (due to a low probability of success, test takers may be inclined to disengage when presented with difficult items; Pintrich & Schunk, 2002). In regard to level-2, it was hypothesized that noneffortful responding would be observed to be lower for test takers at institutions designated

by their respective country to be a major research university (hereon referred to as elite universities) as: (a) higher achieving students were assumed to attend elite universities, and (b) lower achieving students have been found to have higher rates of noneffortful responding (Rios et al., 2017). Furthermore, we investigated whether university type moderated the relationship between each level-1 independent variable (gender, year, prior ability, and perceived test difficulty) and noneffortful responding.

To test these research questions, the following intercepts- and slopes-as-outcomes two-level model (allowing for random variation in university intercepts and slopes) was specified as:

$$\begin{aligned}
 Y_{ij} = & \gamma_{00} + \gamma_{10}Gender_{ij} + \gamma_{20}Year_{ij} + \gamma_{30}PriorAbility_{ij} + \gamma_{40}TestDifficulty_{ij} \\
 & + \gamma_{01}Elite_j + \gamma_{11}Elite_jGender_{ij} + \gamma_{21}Elite_jYear_{ij} \\
 & + \gamma_{31}Elite_jPriorAbility_{ij} + \gamma_{41}Elite_jTestDifficulty_{ij} + U_{1j}Gender_{ij} \\
 & + U_{2j}Year_{ij} + U_{3j}PriorAbility_{ij} + U_{4j}TestDifficulty_{ij} + U_{0j} + r_{ij}
 \end{aligned} \tag{3}$$

where:

Y_{ij} = the number of noneffortful responses for test taker i nested in university j ;

$Gender_{ij}$ = a fixed-effect level-1 predictor (dichotomously coded as male/female);

$Year_{ij}$ = a fixed-effect level-1 predictor (dichotomously coded as upperclassmen [juniors and seniors]/underclassmen [freshmen and sophomores]);

$PriorAbility_{ij}$ = a random-effect level-1 predictor based on self-reported college admission test scores (this variable was standardized);

$TestDifficulty_{ij}$ = a fixed-effect level-1 predictor based on a single posttest survey Likert question that asked students to rate the difficulty of the CT assessment (coded dichotomously as very difficult or average/not difficult);

γ_{00} = overall mean intercept adjusted for gender, year, prior ability, and test difficulty;

γ_{10} = overall mean intercept adjusted for gender;

γ_{20} = overall mean intercept adjusted for year;

γ_{30} = overall mean intercept adjusted for year;

γ_{40} = overall mean intercept adjusted for test difficulty;

γ_{01} = regression coefficient associated with gender, year, prior ability, and test difficulty relative to level-2 intercept;

γ_{11} = regression coefficient associated with gender relative to level-2 intercept;

γ_{21} = regression coefficient associated with year relative to level-2 intercept;

γ_{31} = regression coefficient associated with prior ability relative to level-2 intercept;

γ_{41} = regression coefficient associated with test difficulty relative to level-2 intercept;

U_{0j} = random effects of the j^{th} level-2 unit adjusted for gender, year, prior ability, and test difficulty on the intercept;

U_{1j} = random effects of the j^{th} level-2 unit adjusted for gender on the intercept;

U_{2j} = random effects of the j^{th} level-2 unit adjusted for year on the intercept;

U_{3j} = random effects of the j^{th} level-2 unit adjusted for prior ability on the intercept;

U_{4j} = random effects of the j^{th} level-2 unit adjusted for test difficulty on the intercept;

r_{ij} = random error associated with test taker i in university j ;

$U_{1j}Gender_{ij} + U_{2j}Year_{ij} + U_{3j}PriorAbility_{ij} + U_{4j}TestDifficulty_{ij} + U_{0j} + r_{ij}$ can be conceived as the composite error in the model.

Visual inspections of residual plots for deviations of homoscedasticity or normality were conducted. Based on these visual inspections, a Box-Cox power transformation of the dependent

variable (i.e., raising the dependent variable to a specified lambda value⁴) was employed to improve the normality of residuals, and all analyses were conducted on the transformed data. Furthermore, highly influential observations were identified at both levels-1 and -2 via Cook's distance measure based on a cutoff criteria of $4/n$ (Bollen & Jackman, 1990) and were removed from the final analysis. Degrees of freedom and p-values were obtained using the Satterthwaite approximation in the *lmerTest* package in *R* (Kuznetsova, Brockoff, & Christensen, 2015). As the model tested for each country consisted of 10 unique hypothesis tests, the probability of a type I error was 40%. To control for this familywise error rate, we employed the Benjamini-Hochburg procedure to test statistical significance based on a false discovery rate of 10% (for details of this procedure, readers are referred to Benjamini & Hochberg, 1995). For ease of interpretation, estimates were reported based on back transformations.

Comparing noneffortful responses and scores across countries. As the assessment was administered in different languages, score equivalence could not be assumed due to potential issues of test translation and/or culture (Hambleton et al., 2004). To ensure that the scores across forms were comparable, multiple-group item response theory (IRT) concurrent calibration was employed. This procedure links forms onto the same scale by identifying a set of items that are statistically invariant to serve as an internal anchor (Sireci, Rios, & Powers, 2017). This was done via the following steps in the MDLTM software (von Davier, 2006):

1. Estimated item parameters were obtained by constraining all item parameters to be equal across groups using the unidimensional two-parameter logistic (2PL) model⁵.

⁴ The lambda values employed were .525, .375, and .275 for Countries 2, 3, and 4, respectively.

⁵ Expected a posteriori (EAP) proficiency estimation was employed using the standard normal distribution as a prior with 21θ values and quadrature points ranging from -4 to 4. The maximum number of iterations was set to 1,000 with a convergence criteria of 0.01. EAP was chosen for ability estimation as it has been shown to be one of the most robust IRT estimators to atypical response behaviors (Kim and Moses, 2016).

2. The RMSEA⁶ item fit statistic was used to identify poorly fitting items that are not adequate to be included in the anchor set. For this study, misfit was indicated by $RMSEA > .10$ (e.g., Oliveri & von Davier, 2011).
3. Item parameters for items found to be poorly fitting were unconstrained and allowed to be freely estimated for each country (i.e., providing unique country-specific item parameters).
4. The process of unconstraining item parameters was continued until there were no poorly fitting items under the estimated model. Once this point was reached, all items that were still constrained equal, were treated as the anchor set.

This process was completed twice, once each for unfiltered (i.e., all responses) and filtered data (i.e., excluding noneffortful responses as they were considered to be uninformative to ability estimation). The outcome of this process was to compare model fit, reliability estimates, and obtain directly comparable country-specific mean group ability estimates. To compare model fit, deviance as well as Akaike and Schwarz's Bayesian information criteria (AIC and BIC) fit statistics were examined. The deviance fit statistic was used to statistically test for fit via the Chi-squared test, while the AIC and BIC fit statistics, which are relative fit statistics, provided another source for directly comparing model fit. For each one of the latter fit statistics, better model fit was indicated by a lower value. In regard to reliability, Expected a posteriori (EAP) reliability estimates, which were obtained as:

$$1 - \frac{\text{average posterior variance}}{(\text{variance of EAP} + \text{average posterior variance})}, \quad (4)$$

⁶ The RMSEA is a standardized index of the discrepancy between the observed and the model based item response curves. It indicates the degree of agreement between item response curves. An RMSEA value of zero indicates no differences between the two item response curves (i.e., a perfect fit of the model to the data). Higher RMSEA values indicate larger gaps between these item response curves that refers to increasingly poorer levels of model-data fit (Oliveri & von Davier, 2014, p. 12).

were compared between unfiltered and filtered datasets. Due to differences in the number of parameters estimated, the ability estimates for each country could not be directly compared between filtered and unfiltered data, however, comparability between relative standing by country was permissible. It should be noted that the goal of this analysis was not to make substantive inferences concerning cross-national differences on the construct tested, but rather to evaluate whether the presence of differential noneffortful responding led to divergence in rank-order performance when comparing results that ignored and filtered such responses.

Results

Figure 1 illustrates the Kernel density plots of testing time by country. Based on test takers that encountered all items, the average total testing time across countries ranged greatly (Country 1: *Mean* = 33.28, *SD* = 9.44; Country 2: *Mean* = 21.69, *SD* = 13.32; Country 3: *Mean* = 33.53, *SD* = 12.71; Country 4: *Mean* = 39.82, *SD* = 12.48), providing justification for separately calculating response time thresholds for each country. Although the total testing time differed across countries, over 80% of test takers in each country indicated that the allotted amount of testing time was either “enough” or “more than enough.” An additional source of evidence for sufficient testing time was that the rate of not reached items (i.e., items with a response time of 0 seconds) was minimal across all countries (ranged from 0.97% to 1.86%).

Differential Noneffortful Responding Rates

Validity check. The first validity check was to examine how close the proportion correct rate for identified noneffortful responses was to the chance level (.193). Across all countries, the HYBRID procedure was found to be the most accurate (Table 2). The second validity check was to examine the relationship between the degree of effortful responses (RTE) and both total testing time and test performance. For each country, results demonstrated that as the degree of

effortful responding increased so did total testing time and test performance. These relationships were strongest for the HYBRID procedure across all countries (Table 2). As the HYBRID procedure was found to most accurately identify noneffortful responses with an average proportion correct rate closest to chance level and as this procedure was observed to have the strongest convergent validity with total testing time and test performance, it was used for all further analyses.

Noneffortful responding rates identified via the HYBRID procedure. Results demonstrated clear differences in noneffortful responding between countries. Specifically, the proportion of noneffortful responses relative to all responses (excluding missing responses) was observed to be highest in order for Countries 2 (29.24%), 4 (17.32%), 3 (14.82%), and 1 (5.35%)⁷. Approximately 7.11 ($SD = 8.35$), 4.16 ($SD = 5.07$), 3.77 ($SD = 5.97$), and 1.39 ($SD = 3.21$) noneffortful responses per test taker were observed within Countries 2, 4, 3, and 1, respectively. A one-way ANOVA demonstrated that the average number of noneffortful responses significantly differed by country, $F(3, 19,879) = 51.94, p < .001$. Post hoc analyses using the Games-Howell post hoc criterion for significance indicated that the average number of noneffortful responses was significantly highest for Country 2 when compared to all other countries and significantly lowest for Country 1; no significant difference was observed when comparing Countries 4 and 3 ($p = .06$). Relative to Countries 1, 3, and 4, Country 2's average noneffortful response rate was 0.90, 0.46, and 0.43 SD higher.

Predictors of Noneffortful Responding by Country

⁷ Across the SEC 3 (Country 2: 9.20%; Country 3: 3.03%; Country 1: 1.69%; Country 4: 1.12%) and NT10 (Country 2: 9.79%; Country 3: 7.90%; Country 4: 5.19%; Country 1: 3.09%) procedures, Country 2 was found to have the highest rate of noneffortful responding.

To examine predictors of noneffortful responding by country, a two-level hierarchical linear model was evaluated; however, due to extensive missing data of admission scores for Country 1 (73% missing scores), models were only estimated for Countries 2, 3, and 4 for the purpose of comparability. Results are presented in Table 3. The intercept- and slopes-as-outcomes model revealed that minimal variance in noneffortful responding could be attributed to differences between universities as the intraclass correlations (ICC) for Countries 2, 3, and 4 were approximately 0.01 ($n = 32$), 0.03 ($n = 25$), and 0.07 ($n = 55$), respectively. A significant difference in noneffortful responding by institution type was only observed for Country 2, whereby elite institutions possessed 2.20 less noneffortful responses than non-elite institutions. Significant interactions between institution type and test taker year were indicated for all three countries, suggesting that upperclassmen at elite institutions noneffortfully responded on between 1.13 to 1.67 less items than underclassmen at non-elite institutions.

In regard to level-1 predictors, across all three countries, self-rated test difficulty was a significant predictor of noneffortful responding. Specifically, test takers that rated the assessment as being “very difficult” were found on average to have between 1.24 to 1.34 more noneffortful responses than those that rated the assessment as being “average” or “not difficult.” Gender and year were also found to be significant predictors for Countries 2 and 4 wherein men and upperclassmen had higher rates of noneffortful responding than women and underclassmen, respectively; however, no significant differences for these two predictors were noted for Country 4. In terms of gender, male test takers exhibited 1.31 more noneffortful responses in Country 2 than females, while the difference in Country 4 between these two groups was 1.21. The discrepancy in observed noneffortful responses between upperclassmen and underclassmen was 1.88 and 1.07 for Countries 2 and 4, respectively. An additional significant predictor of

noneffortful responding found was prior ability (as indicated by college admission test scores); however, only for Countries 3 and 4. That is, a one standard deviation increase in college admission test scores was observed to be associated with a decrease of 1.18 and 1.05 noneffortful responses for Countries 3 and 4, respectively.

Impact of Differential Noneffortful Responding on International Comparisons

To evaluate the impact of differential noneffortful responding on international comparisons, we first investigated the difference in model fit between 2PL calibrations for filtered (i.e., treating identified noneffortful responses as missing) and unfiltered (i.e., not considering noneffortful responding) data. A chi-square (deviance) test demonstrated that the model based on filtered data provided statistically better fit than the model based on the unfiltered data ($\Delta\chi^2 = 87302$, $df = 14$, $p < .0001$). This finding was further supported by comparing relative fit indices between the two models, which showed that both AIC and BIC values were lower for the model based on the filtered data (Table 4). Taken together, these findings indicate that removing noneffortful responses for IRT calibration improved model fit. In regard to EAP reliability, estimates for the unfiltered datasets were close to or above .70 for each country; however, lower estimates were consistently obtained when filtering noneffortful responses. This result indicates that including noneffortful responses in the IRT calibration led to inflation of reliability estimates, which was most dramatic as the degree of noneffortful responding increased (Table 4).

In examining the impact of differential noneffortful responding on relative rank-order performance, two findings of importance were noted. First, although estimating data under the same model (unidimensional 2PL model), the anchor length was found to differ between the two datasets. Specifically, for the unfiltered data, 15 of 26 items (58%) were found to possess item

properties that were of an acceptable level of invariance across all four countries; however, only 11 items (42% of total items) met the same criteria for the filtered data. This may have occurred as the inclusion of noneffortful responses resulted in deflating the variability in item difficulty. Consequently, some items may have appeared to artificially possess similar item properties (e.g., item difficulty due to high rates of incorrect responses associated with guessing) than was the case when accounting or filtering for noneffortful responses leading to the disparities in anchor set length. Second, in regard to mean ability, for the unfiltered data, the average performance in order from highest to lowest was observed for Countries 1, 3, 2, and 4. This same order was observed after filtering noneffortful responses (caution should be placed on interpreting ability estimates for Countries 2 and 4 as their reliability estimates were .61 and .65, respectively), which suggests that although there was differential noneffortful responding between countries, relative performance did not change (Figure 2).

Discussion

The objective of this study was to investigate whether there was differential noneffortful responding on an international low-stakes assessment of critical thinking. Results indicated significant differences (as large as $.90 SD$) between nearly all country pairings in the average number of noneffortful responses per test taker. Furthermore, noneffortful responding was found to be associated with a number of individual-level predictors, such as demographics (both gender and academic year), prior ability, and perceived difficulty of the test, however, these predictors were found to differ across countries. In regard to the impact of differential noneffortful responding on measurement properties and score estimation, a number of important findings were observed. First, the inclusion of noneffortful responses were associated with model fit deterioration as well as inflation of reliability, which supports prior research (e.g., Guo et al.,

2017). These findings have implications for test development as well as score interpretations, particularly in regard to biased reliability, which may be associated with inaccurate decisions related to student performance. Second, allowing noneffortful responses to be included in the score linking procedure resulted in the inclusion of non-invariant items in the anchor set. This occurred as noneffortful responding may have been associated with deflated item discriminations as found in prior simulation research (van Barnevald, 2007), and consequently, items appeared more invariant than they actually were when filtering noneffortful responses; however, the degree of bias in the linking process could not be evaluated as this analysis relied solely on applied data. Third, although there were large differences in noneffortful responding, no significant differences in rank-order performance across countries were noted based on available data.

Implications

Overall, the results from our study provide a number of implications for practitioners. First, although there are some international testing programs, such as PIACC, that attempt to identify noneffortful responses as part of operational analyses, they do so by using a simple constant threshold (akin to SEC3) that ignores variability in country-specific item length, reading load, and difficulty (OECD, 2013). This paper demonstrated a new procedure (HYBRID) that provides superior validity evidence to other popular procedures and allows for calculation of country-specific thresholds that may more accurately capture complexities associated with response latencies.

Second, by accounting for noneffortful responses, testing programs can make more precise evaluations of measurement properties (e.g., item properties and reliability estimates) and score linking error, leading to more accurate ability inferences. As an example, ignoring

noneffortful responses may lead to inflated item difficulty parameters (e.g., Guo et al., 2017) and reliability estimates (as shown in this study; Wise & DeMars, 2009). Consequently, testing programs may overestimate engaged test takers' ability (i.e., answering an item correctly that has an inflated estimated item difficulty, may make an engaged test taker appear more able than is actually the case based on the true item difficulty) and underestimate the amount of error associated with these ability estimates. Furthermore, filtering noneffortful responses may help to avoid systematic score reporting errors that may disadvantage some countries due to the inclusion of noninvariant items in the anchor set when linking scores across countries. Such errors may have significant negative consequences due to the potential high-stakes nature of international assessments for educational stakeholders and policy makers.

Finally, by demonstrating differential predictors of noneffortful responding by country, this study points out the potential for educational stakeholders to make inaccurate inferences when comparing subgroup performance across countries. As an example, if comparing performance by gender, it is possible that score differences observed between males and females within and across countries may be confounded by test-taking effort as opposed to true differences. As such relationships may be examined as a basis for prescribing national education policy reform, it is important that noneffortful responses are identified and filtered before operational analyses (e.g., item analyses and score linking) and research analyses are conducted. This suggestion is supported by Standard 13.9 of the *Standards for Educational and Psychological Testing*, which states that an investigation of “the degree of motivation of the test takers” should be employed to determine the validity of the overall interpretation of test scores (AERA, APA, & NCME, 2014, p. 213).

Limitations and Future Research

The findings from this study are limited in a number of ways. First, as with any international assessment, there is a concern about the equivalence of how the construct is conceptualized, functions, and operationalized across cultures. To address this concern, educational researchers in each participating country reviewed both the critical thinking operational definition and test items to evaluate the test's appropriateness for each respective population. Though this process relied on subjective judgments, no issues were noted by the reviewers, however, concerns about construct conceptualization across countries should be considered when interpreting the results from this study. In addition, adapting a test from one language to multiple languages is a difficult task. To mitigate errors in the adaptation process, we: (a) hired a professional translation company that employs translators with knowledge of both the target language and culture to conduct the adaptations, (b) had independent researchers knowledgeable of the target language, culture, and construct review the translation company's work, (c) pilot tested the assessment with university students in each participating country, and (d) conducted analyses to demonstrate construct equivalence. Though these efforts were extensive, as with any adaptation, it is possible that the measure was not perfectly comparable across all participating countries.

Beyond issues of the measure itself, the results from this study cannot be generalized to other testing contexts or specific test-taking populations (not even those examined in this paper as we were unable to divulge the countries studied) as the data come from the administration of a single-college level assessment to four countries. Thus, from this study, readers can simply speculate from one applied example that culture may be a salient predictor of noneffortful responding, which may potentially motivate international comparative testing programs to examine the presence of differential test-taking engagement prior to making cross-cultural

comparisons. Though, there clearly is a need for continued research in this area, particularly for test-taking populations that vary in age, native language, and nationality, as well as assessments that go beyond traditional constructs (e.g., math, reading, and science) and include item types other than selected-response items. Additionally, as noted by Rios et al. (2017), additional development and validation of procedures to identify noneffortful responding is necessary. The current proxies of test-taking effort, including the one used in this study, are indirect sources that have their own assumptions concerning behavior. Thus, there is a need for multimodal approaches (e.g., eye tracking and key-stroke behavior) that combined may be able to provide a more complete evaluation of testing behavior. If these multimodal approaches are not scalable, they may be used in small-scale studies to provide validity evidence for current approaches that are more easily collected (e.g., response latencies) during large-scale test administrations.

In regard to a more technical measurement aspect, there is a need to study how noneffortful responding could affect ability estimation when employing multiple-group IRT concurrent calibration for score linking. As demonstrated in this study, the inclusion of noneffortful responses in the calibration procedure can lead to the inclusion of non-invariant items in the anchor set, which has been shown to be associated with biased linking results (e.g., Huggins, 2014); however, it is unclear what the degree of ability estimate bias would be under realistic conditions of noneffortful responding. Such work could elucidate the practical impact of low test-taking effort on international comparisons. Finally, as extensive rates of noneffortful responding were illustrated in this study, international assessment programs should consider establishing interventions for improving students' test-taking effort before or during the test administration (see Wise & DeMars, 2005). These interventions are numerous and span over 70 years, however, there has been limited work conducted in international testing contexts (see Rios

& Liu, 2018). Clearly, future research is needed to better understand whether the utility of specific interventions is invariant across cultures. Regardless, it is our hope that this study brings further attention to the role of test-taking effort in international assessments, and adds to the discussion of investigating test takers' effort as part of standard operational practices.

References

- American Educational Research Association, American Psychological Association, & National Council for Assessment in Education. (2014). *Standards for educational and psychological testing*. Washington, DC: AERA.
- Bates, D., Maechler, M., Bolker, B., & Walker, S. (2018). *Package 'lme4'*. Package version 1.1-17.
- Benjamini, Y., & Hochberg, Y. (1995). Controlling the false discovery rate: a practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society: Series B (Methodological)*, 57, 289-300.
- Boe, E. E., & May, H. M. (2002). *Student task persistence in the Third International Mathematics and Science Study: A major source of achievement differences at the national, classroom, and student levels* (Research Report No. 2002-TIMSS1). Center for Research and Evaluation in Social Policy, University of Pennsylvania, Philadelphia, PA.
- Bollen, K. A., & Jackman, R. W. (1990). Regression diagnostics: An expository treatment of outliers and influential cases. *Modern Methods of Data Analysis*, 13, 257-291.
- Brown, G. T. L., & Harris, L. R. (2016). *Handbook of human and social conditions in assessment*. New York, NY: Routledge.
- Debeer, D., Buchholz, J., Hartig, J., & Janssen, R. (2014). Student, school, and country differences in sustained test-taking effort in the 2009 PISA reading assessment. *Journal of Educational and Behavioral Statistics*, 39, 502-523.
- DeMars, C. E., Bashkov, B. M., & Socha, A. B. (2013). The role of gender in test-taking motivation under low-stakes conditions. *Research and Practices in Assessment*, 8, 69-82.
- Eklöf, H., Pavešič, B. J., and Grønmo, L. S. (2014). A cross-national comparison of reported

- effort and mathematics performance in TIMSS Advanced. *Applied Measurement in Education*, 27, 31-45.
- Gneezy, U., List, J. A., Livingston, J. A., Sadoff, S., Qin, X., & Xu, Y. (2017). *Measuring success in education: The role of effort on the test itself* (Research Report No. w24004). National Bureau of Economic Research, Cambridge, MA.
- Goldhammer, F., Martens, T., Christoph, G., & Lüdtke, O. (2016). *Test-taking engagement in PIAAC* (OECD Education Working Papers, No. 133). Paris, France: OECF Publishing.
- Goldhammer, F., Martens, T., & Lüdtke, O. (2017). Conditioning factors of test-taking engagement in PIAAC: An exploratory IRT modelling approach considering person and item characteristics. *Large-Scale Assessments in Education*, 5 (18), 1-25.
- Guo, H., Rios, J. A., Haberman, S., Liu, O. L., Wang, J., & Paek, I. (2016). A new procedure for detection of students' rapid guessing responses using response time. *Applied Measurement in Education*, 29, 173-183.
- Hambleton, R. K., Merenda, P. F., & Spielberger, C. D. (2004). *Adapting educational and psychological tests for cross-cultural assessment*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, 6, 1-55.
- Huggins, A. C. (2014). The effect of differential item functioning in anchor items on population invariance of equating. *Educational and Psychological Measurement*, 74, 627-658.
- Kam, C. C. S., & Meyer, J. P. (2015). How careless responding and acquiescence response bias

- can influence construct dimensionality: The case of job satisfaction. *Organizational Research Methods*, 18, 512-541.
- Kim, S., & Moses, T. (2016). *Investigating robustness of item response theory proficiency estimators to atypical response behaviors under two-stage multistage testing* (ETS RR-16-22). Educational Testing Service, Princeton, NJ.
- Kong, X. J., Wise, S. L., & Bhola, D. S. (2007). Setting the response time threshold parameter to differentiate solution behavior from rapid-guessing behavior. *Educational and Psychological Measurement*, 67, 606-619.
- Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2018). *Package 'lmerTest'*. R package version, 2(0).
- Liu, O. L., Frankel, L., & Roohr, K. C. (2014). Assessing critical thinking in higher education: Current state and directions for next-generation assessment. *ETS Research Report Series*, 2014(1), 1-23. doi:10.1002/ets2.12009
- Liu, O. L., Mao, L., Frankel, L., & Xu, J. (2016). Assessing critical thinking in higher education: The HEIghten approach and preliminary validity evidence. *Assessment & Evaluation in Higher Education*, 41, 677-694.
- Matsumoto, D., & van de Vijver, F. J. R. (2011). *Introduction to the methodological issues associated with cross-cultural research*. New York, NY: Cambridge University Press.
- Mittelhaeuser, M. A., Béguin, A. A., & Sijtsma, K. (2015). The effect of differential motivation on IRT linking. *Journal of Educational Measurement*, 52, 339-358.
- Oliveri, M. E., & von Davier, M. (2011). Investigation of model fit and score scale comparability in international assessments. *Psychological Test and Assessment Modeling*, 53, 315-333.
- Organisation for Economic Co-Operation and Development (OECD) (2013). *Technical report of*

- the Survey of Adult Skills (PIAAC)*. Paris: OECD.
- Osborne, J. W., & Blanchard, M. R. (2011). Random responding from participants is a threat to the validity of social science research results. *Frontiers in Psychology, 1*, 220.
- Penk, C., & Schipolowski, S. (2015). Is it all about value? Bringing back the expectancy component to the assessment of test-taking motivation. *Learning and Individual Differences, 42*, 27-35.
- Pintrich, P. R., & Schunk, D. H. (2002). *Motivation in education: Theory, Research, and Applications* (2nd ed.). Columbus, OH: Merrill Prentice Hall.
- Pizmony-Levy, O., Harvey, J., Schmidt, W. H., Noonan, R., Engal, L., Feuer, M. J., ... Torney-Purta, J. (2014). On the merits of, and myths about, international assessments. *Quality Assurance in Education, 22*, 319 – 338.
- R Core Team (2019). R: A language and environment for statistical computing [Computer software]. R Vienna, Austria: Foundation for Statistical Computing. Retrieved from <http://www.R-project.org/>
- Rios, J. A., Guo, H., Mao, L., & Liu, O. L. (2017). Evaluating the impact of noneffortful responses on aggregated scores: To filter unmotivated examinees or not? *International Journal of Testing, 1*, 74-104.
- Rios, J. A., & Liu, O. L. (2017). Online proctored versus unproctored low-stakes internet test administration: Is there differential test-taking behavior and performance? *American Journal of Distance Education, 31*, 226-241.
- Rios, J. A., & Liu, O. L. (2018, April). *Improving test-taking effort in low-stakes group-based educational testing: A meta-analysis of interventions*. Paper presented at the annual meeting of the American Educational Research Association, New York, NY.

- Schnipke, D. L., & Scrams, D. J. (1997). Modeling item response times with a two-state mixture model: A new method of measuring speededness. *Journal of Educational Measurement, 34*, 213-232.
- Sireci, S. G., Rios, J. A., & Powers, S. (2017). Comparing scores from tests administered in different languages. In N. J. Dorans, & L. L. Cook (Eds.), *Fairness in educational assessment and measurement* (pp. 181 - 202). New York, NY: Routledge.
- van Barnevald, C. (2007). The effect of examinee motivation on test construction within an IRT framework. *Applied Psychological Measurement, 31*, 31-46.
- von Davier, M. (2006). *Multidimensional latent trait modelling (MDLTM)* [Software program]. Princeton, NJ: Educational Testing Service.
- Wigfield, A., & Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology, 25*, 68-81.
- Wise, S. L. (2009). Strategies for managing the problem of unmotivated examinees in low-stakes testing programs. *The Journal of General Education, 58*, 152-166.
- Wise, S. L. (2017). Rapid-guessing behavior: Its identification, interpretation, and implications. *Educational Measurement: Issues and Practice, 36*, 52-61.
- Wise, S. L., & DeMars, C. E. (2005). Examinee motivation in low-stakes assessment: Problems and potential solutions. *Educational Assessment, 10*, 1-18.
- Wise, S. L., & DeMars, C. E. (2009). A Clarification of the effects of rapid guessing on Coefficient α : A note on Attali's "reliability of speeded number-right multiple-choice tests". *Applied Psychological Measurement, 33*, 488-490.
- Wise, S. L., & DeMars, C. E. (2010). Examinee noneffort and the validity of program assessment results. *Educational Assessment, 15*, 27-41.

- Wise, S. L., & Kong, X. (2005). Response time effort: A new measure of examinee motivation in computer-based tests. *Applied Measurement in Education*, 18, 163-183.
- Wise, S. L., & Ma, L. (2012, April). *Setting response time thresholds for a CAT item pool: The normative threshold method*. Presented at the annual meeting of the National Council on Measurement in Education, Vancouver, Canada.
- Wise, S. L., Ma, L., Cronin, J., & Theaker, R. A. (2013, April). *Student test-taking effort and the assessment of student growth in evaluating teacher effectiveness*. Presented at the annual conference of the American Educational Research Association, San Francisco, CA.
- Wise, S. L., & Smith, L. F. (2016). The validity of assessment when students don't give good effort. In G. T. L. Brown & L. R. Harris (Eds.), *Handbook of Human and Social Conditions in Assessment* (pp. 204-220). New York, NY: Routledge.

Table 1

Sample demographics by country

Variable	Country			
	1	2	3	4
Total Sample Size	3,186	3,574	1,679	11,440
Language Tested	English	Non-English	Non-English	English
Gender				
Male	1,468 (46.1%)	1,978 (55.3%)	1,132 (67.4%)	7,356 (64.3%)
Female	1,379 (43.3%)	870 (24.3%)	687 (22.2%)	4,070 (35.6%)
Missing	339 (10.6%)	726 (20.3%)	175 (10.4%)	14 (0.001%)
Grade				
Underclassmen (Freshmen and Sophomores)	2,376 (74.6%)	2,377 (66.5%)	992 (59.1%)	5,415 (47.3)
Upperclassmen (Juniors and Seniors)	810 (25.4%)	1,197 (33.5%)	687 (40.9%)	6,025 (52.7%)
Universities				
Number of Universities	49	36	34	168
Number of Elite Universities	11 (22.4%)	7 (19.4%)	6 (17.6%)	50 (29.7%)
Median <i>n</i> per university (SD)	65.02 (173.83)	99.31 (77.75)	49.17 (21.86)	68.10 (45.35)
Range	(1 - 1,096)	(9 - 475)	(13 - 96)	(6 - 646)

Table 2

Validity checks for threshold procedures

Country	Threshold Procedure	Proportion Correct	$r_{RTE,time}$	$r_{RTE,score}$
1	SEC3	.249	.215	.327
	NT10	.220	.248	.408
	HYBRID	.208	.287	.472
2	SEC3	.241	.684	.610
	NT10	.233	.778	.691
	HYBRID	.226	.842	.784
3	SEC3	.245	.491	.384
	NT10	.238	.596	.498
	HYBRID	.220	.669	.629
4	SEC3	.227	.240	.078
	NT10	.251	.409	.225
	HYBRID	.219	.525	.409

Note. RTE stands for response time effort, which is the percentage of responses classified as being valid or effortful. RTE values were calculated based on complete data. Chance level was .193.

Table 3

Mixed hierarchical linear model moderator results

Fixed Effects	Estimate	Country 2			Estimate	Country 3			Estimate	Country 4		
		95% CI	<i>t</i>	<i>p</i>		95% CI	<i>T</i>	<i>p</i>		95% CI	<i>t</i>	<i>p</i>
Intercept	3.44	[2.93, 3.99]	11.82	<.001*	1.88	[1.65, 2.13]	8.58	<.001*	2.13	[2.02, 2.25]	21.95	<.001*
Elite	-2.20	[-3.45, -1.23]	2.55	.01*	-1.28	[-1.75, -0.87]	1.31	.19	-1.14	[-1.36, -0.94]	1.44	.15
Gender	1.31	[1.12, 1.52]	3.26	<.01*	1.10	[0.94, 1.27]	1.23	.22	1.21	[1.15, 1.27]	6.74	<.001*
Year	1.88	[1.65, 2.13]	8.50	<.001*	1.13	[0.99, 1.28]	1.88	.06	1.07	[1.01, 1.13]	2.59	<.01*
Admission Score	-1.10	[-1.27, -0.94]	1.33	.18	-1.18	[-1.26, -1.09]	4.22	<.001*	-1.05	[-1.09, -1.01]	2.13	<.05*
Test Difficulty	1.32	[1.11, 1.55]	3.09	<.01*	1.34	[1.13, 1.58]	3.30	<.001*	1.24	[1.14, 1.35]	4.38	<.001*
Elite * Gender	1.05	[0.55, 1.71]	0.16	.87	1.11	[0.79, 1.49]	0.66	.51	-1.08	[-1.25, -0.92]	1.00	.32
Elite * Year	-1.67	[-2.44, -1.04]	2.12	.03*	1.51	[1.15, 1.91]	2.92	<.01*	-1.13	[-1.26, -1.01]	1.99	.04*
Elite * Admission Score	1.12	[0.93, 1.34]	1.11	.27	-1.00	[-1.21, -0.81]	0.01	.99	-1.07	[-1.15, -0.99]	1.55	.13
Elite * Test Difficulty	1.07	[-.59, 1.68]	0.28	.78	-0.88	[-1.40, -0.48]	0.45	.65	1.04	[0.78, 1.34]	0.27	.79
Random Components												
N _{university}		32			25			55				
ICC _{university}		.010			.034			.066				
N _{test takers}		2,456			1,141			3,716				

Note. *t*-values are presented as absolute values. *Statistical significance was based on critical values obtained from the Benjamini-Hochberg procedure assuming a false discovery rate of 10%.

Table 4

Model fit, reliability, and ability estimates for filtered and unfiltered data

Data Type	Model Fit			Country	Item and Person Parameter Estimates			
	Deviance	AIC	BIC		EAP Reliability	$\bar{a}$ (SD)	$\bar{b}$ (SD)	$\bar{\theta}$ (SD)
Unfiltered	570615.10	570785.10	571456.70	1	.79	1.00 (0.43)	0.16 (0.65)	0.18 (0.73)
				2	.80	1.21 (0.90)	0.08 (0.49)	-0.22 (0.68)
				3	.78	1.00 (0.51)	0.11 (0.66)	-0.15 (0.71)
				4	.69	1.07 (0.59)	0.14 (0.63)	-0.51 (0.65)
Filtered	483313.00	483511.00	484293.20	1	.75	1.00 (0.47)	0.35 (1.27)	0.21 (0.70)
				2	.61	1.05 (0.69)	0.33 (1.59)	-0.14 (0.64)
				3	.70	1.03 (0.53)	0.40 (1.30)	-0.03 (0.66)
				4	.65	1.06 (0.55)	0.34 (1.27)	-0.51 (0.65)

Note. The item and person parameter estimates should not be directly compared as the filtered and unfiltered models were based on a different number of estimated parameters. $\bar{a}$ is equal to the mean slope parameter estimate, $\bar{b}$ is equal to the mean difficulty parameter estimate, and $\bar{\theta}$ is equal to the mean ability estimate.

Figure 1. Kernel density plots of total testing time by country.

Figure 2. Average theta by country for unfiltered and filtered data.